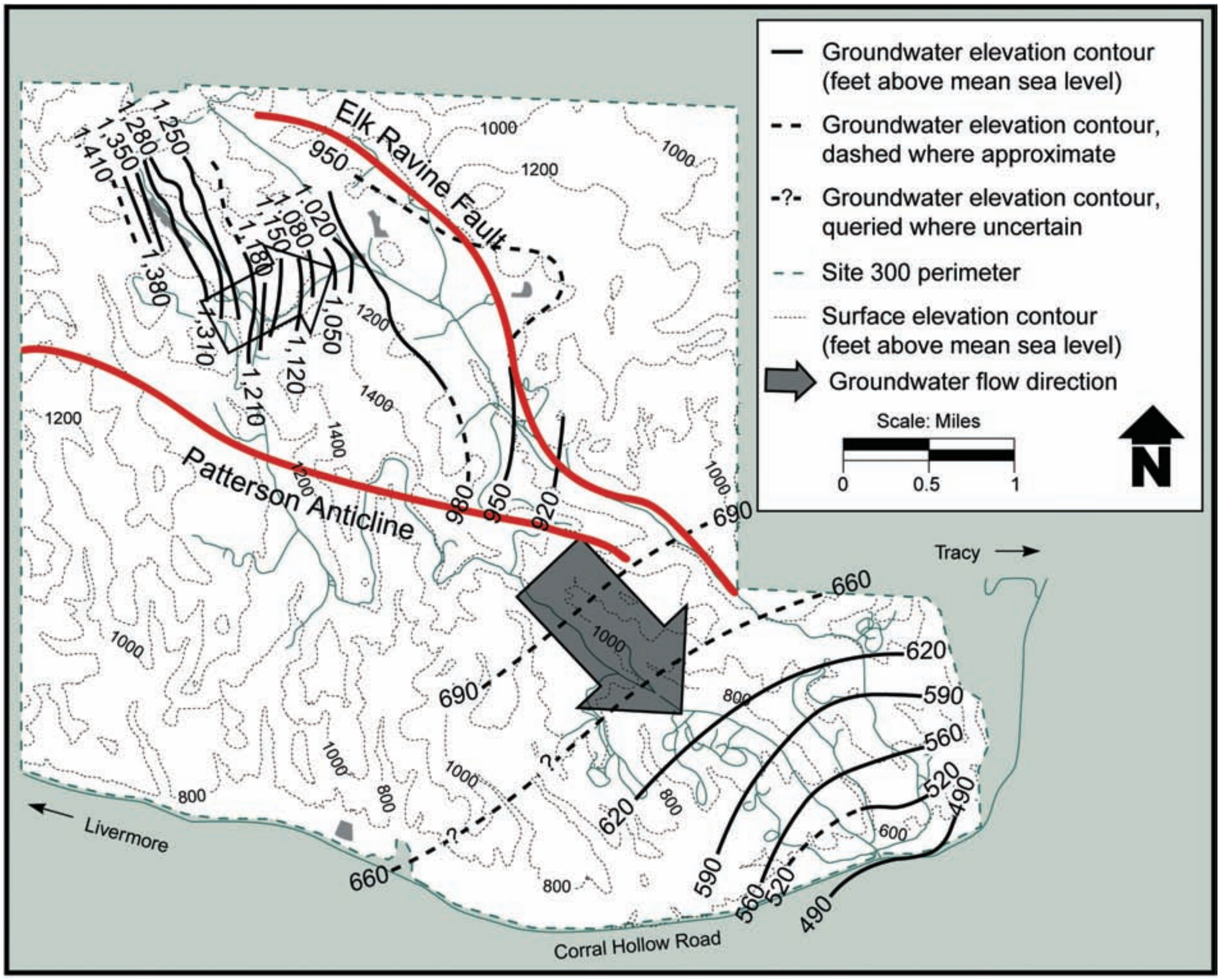


Source: LLNL 2003l.

FIGURE 4.11.3.2–4.—*Approximate Groundwater Surface Elevations and Flow Direction in the Principal Site 300 Water-Bearing Zones*

4.11.3.3 *Background Groundwater Quality*

Livermore Site

Groundwater near the Livermore Site is generally suitable for use as a domestic, municipal, agricultural, and industrial supply; however, use of some shallower groundwater may be limited by its marginal quality. Groundwater less than 300 feet deep is usually unsuitable for domestic use without treatment (LLNL 1992a).

Groundwater in the vicinity of the Livermore Site is mostly a calcium-bicarbonate type, with sodium-chloride waters to the northeast. The maximum concentrations observed for most metals exceed EPA drinking water MCLs; however, the maximum concentrations are usually confined to limited areas. Elevated levels of sodium, hardness, total dissolved solids, specific conductance, and nitrate also exceed EPA water quality standards. High concentrations of boron, chloride, and sulfate limit the use of this groundwater for irrigation. Samples from the Mocho I and Mocho II subbasins (Figure 4.11.3.1–1) have shown that some groundwater is classified as Class II and Class III for irrigation, largely due to high boron concentrations. The high bicarbonate and calcium concentrations may limit the use of this groundwater for livestock. High concentrations of chromium, lead, and manganese may limit the discharge of this groundwater to surface water drainages (LLNL 1992a).

Site 300

Groundwater quality at Site 300 has a relatively high concentration of total dissolved solids, though variability in natural water quality has been observed. Sodium bicarbonate water is most common in water supply wells. The amount of total dissolved solids ranges from 400 parts per million to 4,000 parts per million in local groundwater. Naturally occurring elements such as barium and uranium in rocks and sediments have contributed to elevated levels (LLNL 2002cc).

4.11.3.4 *Groundwater Contamination*

Livermore Site

Groundwater surveillance monitoring at LLNL complies with DOE O 450.1 and remediation monitoring under CERCLA. The following compounds, mostly volatile organic compounds (VOCs), exist in groundwater at various locations in concentrations above drinking water quality standards: trichloroethylene, perchloroethylene, 1,1-dichloroethylene, chloroform, 1,2-dichloroethylene, 1,1-dichoroethane, 1,2-dichloroethane (1,2-DCA), trichlorotrifluoroethane (Freon 113), trichlorofluoromethane (Freon 11), and carbon tetrachloride (LLNL 2003l). See Section 4.17, Site Contamination and Remediation, for additional water quality information.

To determine the fate and transport of contaminants in each hydrostratigraphic unit, personnel in the Environmental Restoration Division at LLNL use three-dimensional groundwater computer models. Groundwater flow and transport models allow for optimization of well extraction rates, evaluation of potential capture zones of proposed extraction wells, and evaluation of plume migration and hydraulic interference patterns under increased pumping conditions.

In 2002, the Livermore Site Groundwater Project treated more than 248 million gallons of groundwater and removed approximately 146 kilograms of VOCs (LLNL 2003l). LLNL removes contaminants from groundwater at the Livermore Site through a system of 27 treatment facilities located throughout the 6 hydrostratigraphic units containing contaminants of concern (LLNL 2002cc). Since remediation began in 1989, approximately 1,960 million gallons of groundwater have been treated (LLNL 2003l). Contaminated groundwater is pumped from individual wells and sent to a treatment facility. If the treated groundwater meets the discharge limits, it is either discharged to surface drainage channels, including Arroyo Las Positas, or routed to the central DRB. Treated water remains in the DRB until it is released to Arroyo Las Positas by way of a stormwater drainage channel.

Livermore Site treatment facilities use a variety of techniques to remove VOCs from groundwater including granular activated carbon, air strippers, and catalytic reductive dehalogenation (CRD). Air-stripping units replaced ultraviolet/hydrogen peroxide systems that had been in use since 1990. Cumulative VOC mass removed from groundwater and soil vapor extraction through 2002 was 1,380 kilograms (LLNL 2003l). The decrease in size and concentration observed in the Livermore Site VOC plumes is consistent with VOC mass removed since remediation began in 1989. Groundwater is also treated at some facilities for chromium (VI), using an ion-exchange unit during the wet season, December though March (LLNL 2002cc).

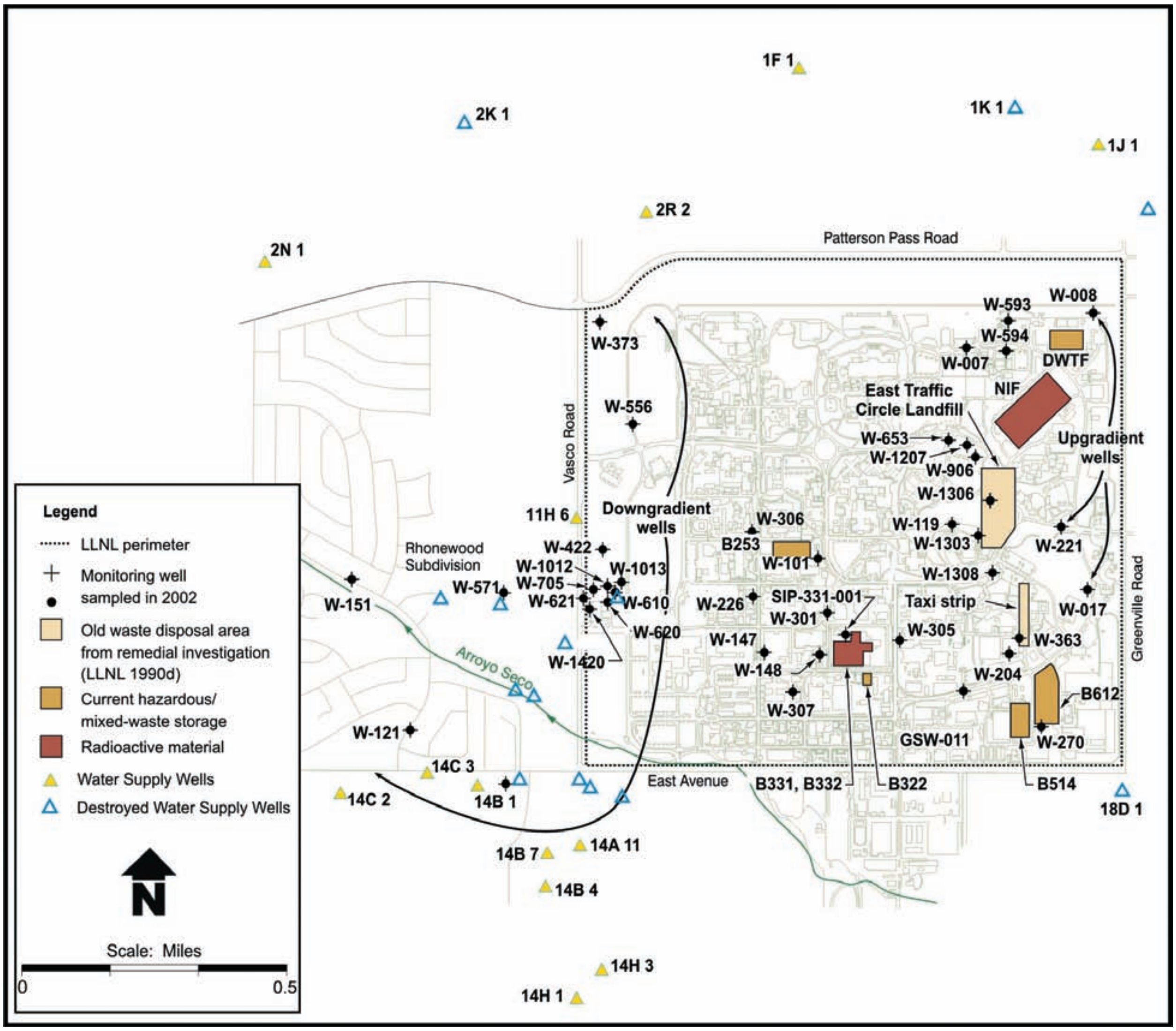
As discussed in the Livermore Site Five-Year Review, from 1996 to 2001, the size and concentrations of VOC plumes had decreased significantly in areas where groundwater extraction and treatment had been implemented (LLNL 1997p). Where groundwater extraction was not occurring, contaminant plumes had migrated, increased in size, or remained unchanged. Along the western margin of the Livermore Site, comprehensive hydraulic containment of all contaminant plumes migrating offsite had been achieved. In the southeastern quadrant, however, total VOC concentrations increased from 521 parts per billion in 2001 to 1,684 parts per billion in 2002. Cleanup in this VOC hot spot is scheduled to begin in 2005. All treatment facilities complied with all permits through 2002 (LLNL 2003l).

Tritiated water is potentially the most mobile groundwater contaminant emanating from the Livermore Site. In August 2002, concentrations of tritium were found at 2,900 ± 300 picocuries per liter (about 15 percent of the MCL) in groundwater from well W-148, downgradient from the Tritium Facility (Building 331). See Figure 4.11.3.4–1 for Livermore Site groundwater monitoring well locations. Groundwater tritium levels had reduced to approximately 2,600 ± 300 picocuries per liter by December 2002 in all the wells sampled downgradient of Building 331. During 2002, tritium groundwater activities in all wells remained below the MCL and continued to decrease by natural decay (LLNL 2003l).

Dissolved chromium has been detected in groundwater samples at the Livermore Site. Groundwater at well W-307, near Building 322, showed a maximum concentration of dissolved chromium of 15 parts per billion, the highest concentration of hexavalent chromium measured in any background well since 1996. Dissolved chromium also has been detected downgradient from the Building 253 catch basin, in wells W-226 and W-306, where concentrations were 10 parts per billion and 40 parts per billion, respectively. No concentrations of either dissolved chromium or hexavalent chromium exceeded the 50 parts per billion total chromium MCL for drinking water (LLNL 2003l).

In 2001, a leaking pipe was discovered connected to a Building 151 mixed-waste retention tank system. It is unknown how long the pipe leaked because it was buried underground. Liquid wastes in this tank system have included various VOCs, trace metals, americium-241, tritium, and various gamma-emitting radioisotopes. Excavations were made around the pipe and soils were analyzed, but no soil contamination was discovered. One upgradient and two downgradient groundwater sampling locations were established to monitor contaminants. VOCs detected in groundwater are being remediated under CERCLA. Concentrations of trace metals, americium, tritium, and gamma-emitting radioisotopes in samples show no indication of being elevated downgradient from Building 151 (LLNL 2002cc).

LLNL currently has in place a storage tank compliance program that is responsible for upgrading and monitoring storage tanks to be certain that they are in compliance with all Federal and state regulations. Information on the storage tank surveillance monitoring program is updated annually and is discussed in detail in the Site Annual Environmental Report.



Source: Hong 2002.

FIGURE 4.11.3.4–1.—*Livermore Site Groundwater Monitoring and Supply Well Locations*

Site 300

The primary contaminants at Site 300 include the solvent trichloroethylene and other VOCs, high explosive compounds, perchlorate, tritium, uranium-238, nitrate, polychlorinated biphenyls (PCBs), silicone-based oil, and metals. In some cases, these compounds have migrated into groundwater as shown on Figure 4.11.3.4–2. Excessive rainfall during the El Niño season (1997 to 1998) contributed to the release of contaminants of concern, mainly tritium in the form of tritiated water, in the Pit 3 and 5 Areas. Because of reduced rainfall since 1998, groundwater elevations have fallen at much of Site 300, thus reducing the potential for releases to occur.

Several groundwater contaminant plumes exist at Site 300 (see Figure 4.11.3.4–2). All contaminant release sites have been assigned to a CERCLA environmental restoration operable unit (OU), based on the nature and extent of contamination and topographic and hydrologic consideration. In the GSA OU, past leaks of solvents from storage areas and buried debris have resulted in three VOC groundwater plumes (LLNL 2002cc). The maximum total VOC concentration in the eastern GSA plume in 2002 was 7.5 parts per billion. VOC plumes in the central GSA had a maximum groundwater concentration of 958 parts per billion. After 8 years of remediation, in 1999, the eastern offsite plume has been restricted to Site 300 property.

VOC and nitrate groundwater plumes are present in the Building 834 OU. The highest VOC concentration of 220,000 parts per billion (predominantly trichloroethylene) occurred in a perched water-bearing zone. This layer has very low hydraulic conductivity, but does yield some groundwater and is hydraulically isolated from the underlying aquifer by more than 295 feet of unsaturated zone. High levels of nitrate; e.g., a maximum 2002 concentration of 280 parts per billion, also occurred in groundwater in the Building 834 OU.

The High Explosives Process Area OU 2002 maximum concentrations of TCE, hexahydro-1,3,5-trinitro-1,3,5-traizine (RDX), nitrate, and perchlorate were 80 parts per billion, 93 parts per billion, 130 parts per billion, and 30 parts per billion, respectively. At Building 854 OU, trichloroethylene, nitrate, and perchlorate plumes had maximum groundwater concentrations of 270 parts per billion, 57 parts per million, and 10 parts per billion, respectively. Building 832 Canyon OU contains groundwater plumes of trichloroethylene, perchlorate, and nitrate at maximum concentrations of 12,000 parts per billion, 11 parts per billion, and 190 parts per million, respectively (LLNL 2003l).

In the past, explosives operations at the Building 850/Pits 3 and 5 OU resulted in releases of tritium and uranium into the groundwater (LLNL 2002cc). In 2002, the maximum tritium activity was approximately 706,000 picocuries per liter in the perched water-bearing zone and 23,700 picocuries per liter in the regional aquifer at the Elk Ravine Fault. Although tritium continues to leach into groundwater, plume activity is decreasing at approximately the radioactive decay rate of tritium (12.3 years). Computer modeling suggests that by the time tritium and depleted uranium in groundwater could reach the Site 300 boundary, both radionuclides would exist at near-background activities. Two smaller depleted uranium plumes had maximum concentrations in 2002 of approximately 118 picocuries per liter and 10.2 picocuries per liter. Both plumes are confined to the perched water-bearing zone. Nitrate and perchlorate maximum concentrations in 2002 were 86 parts per million and 44 parts per billion, respectively.

The Pit 6 OU contains trichloroethylene, perchlorate, and tritium groundwater contaminant plumes with maximum concentrations in 2002 of 5.2 parts per billion, 15 parts per billion, and 1,970 picocuries per liter, respectively (LLNL 2003l). Both tritium and perchlorate plumes are confined to shallow depths in the perched water-bearing zone. No plumes extend beyond the Site 300 boundary. The tritium plume, however, appears to be affected by heavy pumping from offsite Carnegie State Vehicular Recreation Area water supply wells. This plume migration and the associated potential risks are being closely monitored under the CERCLA program. LLNL's CERCLA program is summarized annually in the Site Annual Environmental Report (LLNL 2002cc).

In 2002, 11 treatment facilities treated 24.6 million gallons of groundwater and removed 9.5 kilograms of VOCs. Since remediation efforts began in 1990, more than 226 million gallons of groundwater and 3.93 million cubic meters of vapor have been treated, yielding 231 kilograms of removed VOCs (LLNL 2003l).

For surveillance and compliance monitoring at Site 300, LLNL uses DOE CERCLA wells onsite and private wells and springs offsite. Groundwater samples are measured for organic compounds and general radioactivity at least once a year. Figure 4.11.3.4–3 shows the locations of monitoring wells used for groundwater surveillance. Twelve groundwater-monitoring locations are offsite. Onsite wells monitor a former open-air explosives burn pit, closed landfills, two connected surface water impoundments, and two connected sewer ponds. Two onsite supply wells (well 18 and well 20) are used for surveillance monitoring. Historically, well 18 has shown trace amounts of trichloroethylene. The maximum concentration for 2002 was 0.3 parts per billion, which is equal to 6 percent of the MCL for trichloroethylene. CERCLA studies have not yet determined the source of trichloroethylene in well 18. Well 20 showed no evidence of contamination in 2002 (LLNL 2003l). Trichloroethylene concentrations have decreased below drinking water standards in all offsite wells.

Tritium activity was above background in many of the shallow groundwater surveillance samples obtained during 2002 from Elk Ravine. Tritium, in the form of tritiated water, was released previously near Building 850 and continues to leach into groundwater from vadose zone sources at Building 850. The largest tritiated water plume, which extends eastward more than a mile from a source beneath Building 850, is confined to shallow depths in the Neroly lower blue sandstone unit and overlying alluvium. This confinement is illustrated by comparing the tritium activity of 46,000 picocuries per liter at well NC7-61, which samples the shallowest water-bearing zone, and the tritium activity of 49 picocuries per liter at well NC7-69, which samples the deeper water-bearing zone in this area. Despite past releases, CERCLA modeling studies indicate that tritium concentrations and plume extent are generally diminishing over time.

Natural decay (tritium has a half life of 12.3 years) and slow groundwater velocities (16 – 50 feet per year) will allow released tritiated water to decrease several orders of magnitude below its MCL before it can reach the site boundary and migrate offsite (LLNL 2003l).

The city of Tracy, located northeast of Site 300, uses groundwater from alluvial aquifers in the San Joaquin Valley, which are isolated from contamination at Site 300 by thick claystone layers and a horizontal distance of more than 5 miles. Modeling suggests that contaminants from Site 300 will not affect groundwater used in the Tracy area (LLNL 2000b).